CONFERENCE ON DISARMAMENT

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PROGRESS REPORT TO THE CONFERENCE ON DISARMAMENT ON THE THIRTY-SIXTH SESSION OF THE AD HOC GROUP OF SCIENTIFIC EXPERTS TO CONSIDER INTERNATIONAL COOPERATIVE MEASURES TO DETECT AND IDENTIFY SEISMIC EVENTS

1. The Ad Hoc Group of Scientific Experts to Consider International Cooperative Measures to Detect and Identify Seismic Events, initially established in pursuance of the decision taken by the Conference of the Committee on Disarmament on 22 July 1976, held its thirty-sixth formal session from 26 July to 6 August 1993, in the Palais des Nations, Geneva, under the Chairmanship of Dr. Ola Dahlman of Sweden. This was the twenty-eighth session of the Group, convened under its new mandate by the decision of the Committee on Disarmament at its 48th meeting on 7 August 1979.

2. The Ad Hoc Group is open to all member States of the Conference on Disarmament. It is also open on a standing basis to all non-member States which have been invited upon their request by the Conference on Disarmament to participate in its work. Accordingly, scientific experts and representatives of the following member States of the Conference on Disarmament participated in the session: Australia, Belgium, Canada, China, Egypt, France, Germany, Hungary, India, Indonesia, Italy, Japan, Mexico, Netherlands, Pakistan, Peru, Romania, Russian Federation, Sweden, United Kingdom of Great Britain and Northern Ireland and the United States of America.

3. Scientific experts and representatives from the following non-member States of the Conference on Disarmament participated in the session: Austria, Czech Republic, Finland, New Zealand, Norway, South Africa, Spain and Switzerland.

4. During the session 43 papers containing information on national investigations related to the work of the Group were presented by experts from: Australia, Austria, Canada, Czech Republic, Egypt, Finland, France, Germany, Italy, Japan, Netherlands, Norway, Peru, Romania, Russian Federation, South Africa, Spain, Sweden, United Kingdom and United States of America.

5. The Ad Hoc Group conducted in-depth discussions on the reassessment of the concept of a global system for the exchange of seismic data worked out in its Fifth Report (CD/903), its Sixth Report (CD/1144) and its Report on the Evaluation of GSETT-2 (Conference Room Paper 228). These discussions

were based on material prepared by working groups of participating experts. Several of these working groups thereby finalized their work. The discussions were focused on the overall design and plans for future testing of the concept. A summary of these elaborations is annexed to this progress report.

6. The Ad Hoc Group discussed the schedule and plans for developing, testing and evaluating an experimental International Seismic Monitoring System. This effort, referred to as GSETT-3, is already under way, and builds upon key elements developed in previous tests. The GSETT-3 exercise has three primary objectives that distinguish it from previous tests. These objectives are to:

(a) Develop and test new concepts for an experimental International Seismic Monitoring System, building upon previous experience;

(b) Provide a practical basis upon which to furnish the Conference on Disarmament with timely technical information;

(c) Develop an experimental system that can evolve and adapt to support future requirements that may be required by the Conference on Disarmament.

The current plans call for the full-scale phase of GSETT-3 to begin by 1 January 1995. The Group has adopted a schedule to meet this date as follows:

1993	Define technical concepts
	Begin implementation of station and communications network
	Begin development of experimental International Data Centre
	Begin development and implementation of national facilities
	Begin initial, continuous test operations of the experimental system
1994	Finalize elements of the experimental system
	Finalize participation of countries and stations
	Continue build-up of test operations
1995	Begin full-scale tests
	Begin evaluation of performance.

Those countries which have stations that will form part of the experimental network are urged to make a formal commitment to contribute these facilities in GSETT-3.

7. The Ad Hoc Group agreed to establish working groups to deal with the planning, operation and evaluation of GSETT-3.

8. The Ad Hoc Group discussed cost estimates of the system planned for GSETT-3. The Group noted that the global seismic network being planned for testing draws heavily on prior investments in seismic facilities built on a national basis. An analysis of the costs for GSETT-3 is attached as annex 2. The cost of the eventual system to be tested depends on a number of factors governing the implementation of the future system. Some of the key factors are provided in this annex. Additional guidance on these factors will need to be provided by the Conference on Disarmament before refinements to the cost estimates can be made.

9. The Ad Hoc Group noted with appreciation the convening of two informal technical meetings since its previous session. The first meeting was hosted by Italy in Rome from 1 to 3 March 1993 and had as its purpose to consider seismological procedures. The second meeting was convened by the United States in Lansdowne, Virginia from 29 June to 2 July 1993, to consider issues to assist the Ad Hoc Group in its planning for GSETT-3. Many participants of the Group were able to attend and contribute to these meetings. This aided in the Group's continued work.

10. The Ad Hoc Group received and appreciated briefings from individual delegations on the activities of the Ad Hoc Committee on a Nuclear Test Ban. The Group agreed to invite the Chairman of the Ad Hoc Committee to its next session to give presentations on issues dealt with by the Committee that are relevant to the work of the Ad Hoc Group.

11. The Ad Hoc Group appreciated the offer by Dr. Gerald Duma of Austria to act as a contact person to maintain informal contact with the International Atomic Energy Agency (IAEA).

12. The Group received and discussed a number of proposals for work in the areas of seismic event identification methods, non-seismological monitoring techniques, and for the expansion of the mandate so as to include the consideration of non-seismic methods. No consensus was reached on these proposals. It was agreed that informal consultations would be carried out on these subjects under the aegis of the Chairman and reported upon at the next session of the Group.

13. The Ad Hoc Group suggests that its next session be convened from 7-18 February 1994 in Geneva, or at a date that is most responsive to the needs of the Conference on Disarmament. In addition, the Ad Hoc Group recognizes that, depending on the activities of the Conference on Disarmament, it may become necessary to meet more frequently than in the past.

Annex 1

TESTING AN EXPERIMENTAL INTERNATIONAL
SEISMIC MONITORING SYSTEM (GSETT-3)

1. Objectives

An important goal of the Group of Scientific Experts (GSE) is to develop scientific and technical concepts for an International Seismic Monitoring System (ISMS) and to test these concepts in practical operation.

Following the successful conduct of GSETT-2, and with experience gained from that test, the original concept for an ISMS has been revised. This revision has also taken into account emerging new technologies, some of which were tested during GSETT-2.

The GSE is now planning the development, testing and evaluation of an experimental ISMS. The experimental system should be able to evolve and adapt to support future CD requirements for monitoring a nuclear test ban. It will further provide a practical basis upon which to furnish the CD with the timely technical information required for its deliberations on monitoring and verification.

2. Overall concept and design

This section gives a general overview of the concept and design of the ISMS as envisaged by the GSE. During GSETT-3, the GSE intends to test an experimental ISMS that matches as closely as possible these design concepts.

The essential features of ISMS are to:

- Ensure prompt and convenient provision of reliable data to all participating States for their national verification purposes;

- Provide a cost-efficient service to all participating States;

- Provide rapid acquisition and processing of data from a global network of stations at a central processing facility;

- Provide as much automation as possible in the collection, processing and distribution of data;

- Provide a permanent archive of all data collected or generated by the system;

- Provide data security and quality control;

- Provide an architecture which will permit modifications and improvements as they are judged desirable.

The infrastructure of the ISMS is flexible enough to incorporate the collection, archiving and distribution of data from non-seismic techniques, for example, radioactivity, hydroacoustics and infrasound.

There are three main elements of the envisaged ISMS:

(a) A global network of stations

The Alpha stations consist primarily of arrays, with some three-component stations, and are designed and located to provide detection of seismic events throughout the world. The station waveform data are telemetered continuously to the International Data Centre (IDC), either directly or through an NDC. The NDC should record the station waveforms and log the IDC access to the station to corroborate the data reliability and enable the IDC to recover lost data when communication links fail. Alpha stations should meet GSE criteria for sensitivity, instrumental response, recording hardware and software, operation and management.

The Beta stations provide data supplementary to that provided by the Alpha stations, so that events can be located with improved accuracy. Beta stations are primarily three-component stations, with some arrays. GSE standards for these stations may not be as stringent as for the Alpha stations. Though not telemetered continuously to the IDC, waveform segments can be retrieved automatically by the IDC or by NDCs from continuous data archives at National Data Centres (NDCs) or the individual stations.

Participating States may also make available supplementary data (gamma data) from national and regional networks that are not formally part of the ISMS. Stations are maintained to national standards. Gamma data are available on request, although rapidity of response may vary from one network to another. The IDC will make use of these data according to standard procedures agreed to by the GSE.

(b) National Data Centres (NDCs)

NDCs are the primary users of data from the ISMS to support national verification needs. NDCs (or cooperative regional facilities, in some cases) operate and maintain Alpha and Beta stations according to GSE standards and procedures. The NDCs are responsible for the collection of continuous data from the alpha stations and for ensuring that such data are transmitted to the IDC. Communication links are operated to ensure availability of data to the IDC. Automatic access to Beta data may be at NDCs or at the stations themselves. Gamma data are compiled at the NDCs and submitted to the IDC.

(c) International Data Centre (IDC)

The IDC collects waveform data from Alpha stations (by continuous telemetry) and from Beta stations (as segments, retrieved automatically), and processes these data to produce and distribute a daily bulletin. Automation is incorporated in the IDC's procedures to the greatest extent

possible. All data are authenticated and archived for open access by any participating State. The IDC also collects other seismological information (gamma data) from NDCs. It monitors calibration of the Alpha and Beta stations, and ensures quality control of data.

3. Station requirements

The GSE has defined the minimum technical specifications that should be covered by so-called "ISMS-standard" stations. This does not necessarily mean that these facilities consist of identical technical components, but the components of these systems must meet basic functional and technical requirements. During GSETT-3 as many participating stations as possible should conform to these ISMS standards.

For the instrumentation of such systems the following general design requirements should be taken into consideration: modularity; flexibility; reliability; robustness; incorporation of widely used components; and, low power consumption.

If the selection of the technical components follow these criteria, instruments can be configured in many ways covering the full range from three-component to array stations. Thus, an ISMS station could be tailored to the local conditions and be coupled to the network configuration to produce a uniform detection threshold for monitoring.

An ISMS-standard three-component station would consist of the following elements:

- Three-component broadband seismometers;
- A data acquisition system with digitizers to convert the seismometer output signals into digital form and modules for placing authentication signatures in the data stream;
- Electronics for very accurate synchronization to Universal Time;
- A system for transmitting data to the IDC, either directly or through an NDC (Alpha stations only) or responding to IDC requests for data (Beta stations), as well as for managing the flow, calibration, and archival of the data;
- Devices for data archiving;
- Communication interfaces for data transmission to NDCs and IDC; and
- Data channels for additional input signals (e.g. wind indicators, temperature, and other environmental data) and station status indicators.

Some of the data handling facilities may be at the NDC rather than at the station.

An ISMS-standard array station would consist of all the elements above plus additional vertical component short-period sensors distributed to enhance the signal-to-noise ratio and to provide azimuth and phase identification information. During GSETT-2 the GSE found that arrays were especially effective in detecting small seismic events, both at regional and teleseismic distances.

The station requirements are summarized in table 1.

4. Network definition for the experimental system

Based on experience from previous tests and from results of computer simulation, the GSE proposes that the experimental system should contain a network of 53 Alpha stations and more than 100 Beta stations. The proposed Alpha station locations are shown in figure 1 and the countries are listed in table 2. Twenty-seven of these stations are of the array type and 26 are three-component stations. In the actual station implementation, the locations of some of these stations may be moved with reference to conditions in each country.

From figure 1 it is seen that most of the proposed stations already exist. Some stations conform already with ISMS standards, whereas some will need to be upgraded.

5. Requirements for the experimental IDC

The United States has offered to build and operate an experimental IDC near Washington, D.C. The products and services of the experimental IDC will include:

- an automatically produced event list based on Alpha station data within one hour;

- an automatically produced event list based on Alpha and Beta station data within four hours;

- a final, analyst-reviewed event bulletin within two days.

The IDC should keep an archive of all waveforms and all other data received, all event lists and bulletins produced, event bulletins received from national and regional networks for events detected by the alpha network, detection lists, station information, calibration, travel-time curves, amplitude-distance curves, etc.

The IDC should be an open facility, and all data and processing results should be available to participants for automatic and easy access. Data and processing results not older than 15 days should be available for on-line access, requests should be responded to automatically and promptly, and data older than 15 days should be available within 24 hours.

The IDC should monitor the status of stations and communications within the global system and provide feedback to the stations.

The procedures used at the experimental IDC should follow, as far as possible, the procedures currently envisaged for the eventual IDC. Thus, the procedures should be validated, well documented and follow strict rules and schedules, they should be as automatic as possible and contain (as a goal) no subjective judgement.

Data and results should be stored in the IDC-database and should be reliable and authenticated.

All procedures should be secure and repeatable so that results could be reproducible.

There should be sufficient redundancy in the IDC-system, at least 99 per cent functionality will be required, the time schedule must be adhered to.

The IDC Analysis Software should be available to the participants so that they can repeat the analysis.

The IDC should provide the participants with user support and computing capabilities.

It should be possible to implement improvements to the IDC software easily and rapidly.

It should be possible to incorporate new scientific methods and technological advancements.

The work should be a joint international effort.

6. Schedule of implementation and testing

Most of the Alpha stations which the GSE considers should form part of the experimental network exist today. The GSE intends to seek the support of the actual countries in contributing those stations to the experimental network and to the test. A number of new stations will have to be established and the GSE hopes that this can be achieved through national or cooperative international efforts. Modern, high-speed communication links will need to be established for both the Alpha and Beta stations in the experimental network. The GSE foresees a gradual establishment of the network by adding stations when they are completed or made available.

The introduction of the Beta-stations will also be by a step-by-step procedure and the Group will make further decisions as to the beta-network once it is clear which stations participating countries will contribute to this network.

The Group appreciates the offer by the United States to develop and operate an experimental IDC. The work to establish and test this IDC is under way and stations are being connected on a case-by-case basis.

A plan to conduct an acceptance test in 1994 of the IDC is being developed. The purpose of this acceptance test is to verify that the IDC meets the GSE requirements set forth for the experimental ISMS.

The GSE envisages that full-scale global testing of the experimental international seismic monitoring system can commence on 1 January 1995.

Table 1

STATION REQUIREMENTS FOR AN ISMS STANDARD STATION

Category	Requirement
Pass Band	.02-20 Hz (Alpha and Beta)*
Seismometer Noise	10 dB below Petersons low earth noise model
Calibration	within 5% in amplitude and 5° in phase
Sample Rate	40 samples per second ($\pm$ 50 μs)
Resolution	18 dB below Petersons low noise model
Sensitivity	200 counts/nm @ 3 Hz
System Noise	10 dB below Petersons low earth noise curve
Dynamic Range	126 dB
Linearity	90 dB over the pass band
Timing Accuracy	1 ms (Network standard timing required)
Operating Temperature	-10° C to 45° C
Authentication	required
State of Heath	a minimum of clock status, calibration status, and vault status
Format	must be one of the official GSE formats
Protocol	TCP/IP (beta)
Delay in Transmission	< 15 seconds
Data Frame Length	< 1 second
Data Access	Priority given to IDC, then NDC
Disk Buffer	7 days
Data Availability	greater than 99%
Timely Data Transmission	greater than 98%
Station Location	known within 100 m; relative location of array elements known to within 1 metre
Seismometer Orientation	known within 1 degree
	* 8.0 hertz for stations with "unique" capabilities

Table 2

Participation in GSETT-3, Current Status -- August 1993

The table is based on national working papers submitted to the GSE

Country/Region	Alpha Stations		Beta Stations	Gamma Data	NDC
	Proposed	Committed	Committed	Committed	Committed
Antarctica	3	1	0	-	-
Argentina	1	0	0	No	No
Australia	4	4	10-15	Yes	Yes
Austria	-	-	1	Yes	Yes
Belgium	-	-	0	No	No
Bolivia	1	0	0	No	No
Botswana	1	0	0	No	No
Brazil	1	0	0	No	No
Canada	3	0	0	No	No
Cen. Afr. Republic	1	0	0	No	No
China	3	0	0	No	No
Czech Republic	-	-	1	No	Yes
Denmark	1	0	0	No	No
Egypt	1	1	0	No	Yes
Finland	1	1	4	Yes	Yes
France	-	-	1	No	Yes
Germany	1	0	0	No	No
Hungary	-	-	0	No	No
India	1	0	0	No	No
Indonesia	1	0	1-2	Yes	Yes
Italy	-	-	2-5	Yes	Yes
Ivory Coast	1	0	0	No	No
Japan	1	1	0	Yes	Yes
Kazahkstan	1	0	0	No	No
S. Korea	1	0	0	No	No
Kenya	1	0	0	No	No
Netherlands	-	-	1	Yes	Yes
N. Africa (XAF)	1	0	0	-	-
New Guinea	1	0	0	No	No
New Zealand	-	-	2	Yes	Yes
Norway	3	3	1	No	Yes
Pakistan	1	0	0	No	No
Paraguay	1	0	0	No	No
Peru	-	-	1	Yes	Yes
Romania	-	-	1	Yes	Yes
Russian Rederation	5	3	6	No	Yes
S. America (XSA)	1	0	0	-	-
South Africa	1	1	1	Yes	Yes
Spain	1	1	0	Yes	Yes
Sweden	-	-	0	No	No
Switzerland	-	-	0	No	No
Thailand	1	0	0	No	No
Turkey	1	0	0	No	No
Turmenistan	1	0	0	No	No
United Kingdom	-	-	1	No	Yes
United States	6	6	15-25	Yes	Yes
TOTAL	**53**	**22**	**49-68**	**13-Yes**	**19-Yes**

Figure 1. Preliminary GSETT-3 alpha network. The filled symbols represent existing or planned stations. The open symbols denote additional stations that are proposed to be located in certain general geographical regions so as to improve the global coverage. The additional stations could be chosen either from existing stations or by installation of new facilities.

Annex II

REPORT ON "COST ESTIMATES"

This report provides an outline of the steps that will be required to determine a cost-performance relationship for the operation of an international seismic monitoring system under a Comprehensive Nuclear Test Ban. First, an initial cost estimate is provided for GSETT-3, including the cost of equipment that has already been developed under the previous GSE exercises and other national seismic programs. Second, the range of costs are provided for individual seismic installations that could be needed in any future international CTB monitoring network. Third, a list of questions are provided which will need to be answered before realistic estimates of the cost of a CTB international seismic monitoring system can be given.

1. GSETT-3: Since the seismic system for GSETT-3 has not yet been precisely defined, it is premature to give final cost estimates. The total cost will not be known until the experiment is completed. However, considering that a fairly long lead time is required for building and upgrading some new stations, the following provides initial estimates for the exercise.

The global seismic network being planned for the test draws heavily on prior investments in seismic facilities built on a national basis. From costs provided by GSE participants, these investments are roughly estimated to have been 150 MUSD. In addition to these investments, there are additional new costs associated with the planned test. These additional costs include new investments in seismic stations and arrays, communications from these seismic facilities to the International Data Center, and the annual operational cost of the stations, national data centres, and the International Data Center. These estimates of the new costs were developed using information provided by the United States, Sweden, and Japan.

Assumptions on the overall configuration of the GSETT-3 exercise

- Alpha Network

(i) 30 arrays and 20, 3-component stations.

Among them 5 new arrays are to be built and 15 stations are to be upgraded.

Currently available facilities are to be utilized as much as possible.

(ii) One IDC will be used.

- Beta Network

(i) Number of Beta stations: about 100

Rough Total Cost Estimates

- Total of past investment and new investment: about 170 MUSD

- Total operating costs: 26 MUSD/year

Rough Costs of Individual GSETT-3 Elements

- For Alpha Network

  New investment: 12 MUSD

  Running cost (including comms): 12 MUSD/year

- IDC:

  New investment: 3 MUSD

  Running cost: 6 MUSD/year

- For Beta Network:

  New investment: 4 MUSD

  Running cost (including comms): 8 MUSD/year

2. The range of costs for individual seismic installations which could be required by an international seismic monitoring network:

- Seismic Arrays:

  New investment: 1 MUSD - 10 MUSD

  Running cost (including comms): 50 KUSD/year to 500 KUSD/year

- Three Component Seismic Stations:

  New investment: 200 KUSD - 2 MUSD

  Running cost (including comms): 20 KUSD/year to 450 KUSD/year.

3. Additional Information that is Required for Estimating Future Costs:

Upon the completion and evaluation of GSETT-3, we will know the true cost of operating an experimental network of proven capability, and we will be able to compare these to our initial theoretical estimates. In addition, before reasonable estimates can be given for the costs and capabilities of future networks, the following information, which depends on political decisions, will be needed. Depending on the answers to the following questions, the cost estimate could vary by as much as an order of magnitude.

(i) The monitoring strategy in the placement and number of stations

- equal coverage or "areas of high interest"

(ii) The cost of maintaining a high - reliability network

- redundancy in sensors and communication

(iii) The monitoring requirement of confidence in event detection

- either high or low at a particular seismic magnitude level

(iv) The administrative overhead of running an IDC - this cost could easily exceed the technical costs.

(v) The costs borne by individual countries in running their network and NDC in a operational mode, including the costs of refurbishing elements of their network over time.

(vi) The cost of facility security and data authentication.